

Accelerator Physics Exercises No. 4

- *Answers to be handed in on 24 November 2022*

Question 4.1

Assume you are designing the RF system for a modern accelerator. Describe the process and the steps of transferring power from the grid to the beam. Discuss technology options available and justify your choices.

Question 4.2

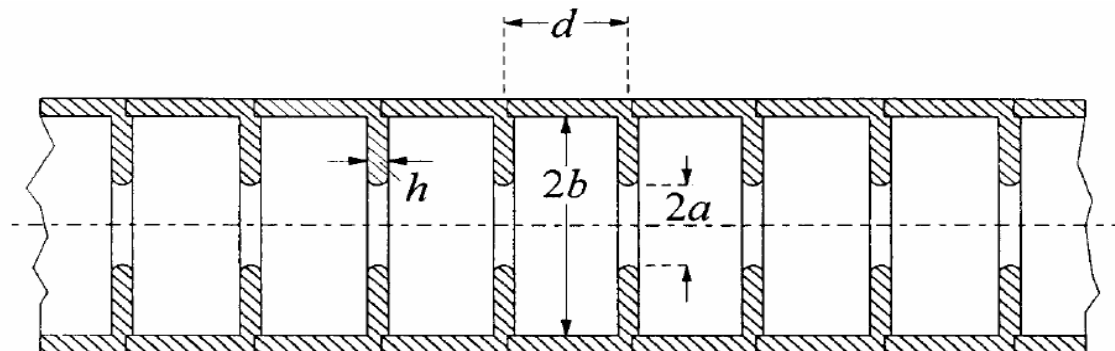
The SLAC accelerating linac structure has the design shown in the figure below with the following dimensions:

$$2b = 82.474 \text{ mm.}$$

$$2a = 22.606 \text{ mm.}$$

$$h = 5.842 \text{ mm.}$$

$$d = 35.001 \text{ mm.}$$



Assuming that the cavities are operated in the $2\pi/3$ mode with a phase velocity $\beta_z = 1$ and a supplied power of 35 MW, what is the total accelerating voltage and energy gain per metre for a SLAC structure of length $l = 3 \text{ m}$?

Question 4.3

Using SuperFish, design a 10 MHz normal conducting pill-box cavity. Assuming an accelerating gradient of 3 MV/m, present your findings including the key figures of merit. What is the transit-time factor for protons of 4 GeV (kinetic energy) being accelerated with this cavity?

Question 4.4

A new 50 GeV (kinetic energy) proton synchrotron, the PS2 accelerator, has been

proposed to replace the CERN PS. The new PS2 will be in a new ring tunnel of mean radius 215 m. and will receive an injected beam at 4 GeV (kinetic energy) from a new linear accelerator - the Superconducting Proton Linac (SPL). The 1.8 T magnetic field of the bending magnets is excited by a sine wave oscillating between injection and top energy at a frequency of 0.3 Hz. Given that the mass of the proton is 0.9383 GeV:

- a)** What is the revolution frequency at 4 GeV, 20 GeV and 50 GeV?
- b)** Assuming the revolution frequency at 20 GeV, calculate the voltage per turn necessary to match the maximum rate of the rise of the field.
- c)** If $\sin \phi_s = \sin 60^\circ$, what is the peak voltage necessary in the cavity? Note that $\phi_s=0$ corresponds to the zero crossing of the accelerating voltage and the particle is not accelerated.
- d)** Given a harmonic number of 32, what are the RF frequencies at 4 GeV and 50 GeV for $\phi_s=0$?